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The transmission of pressure through sand and earth

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THE TRANSMISSION OF PRESSURE THROUGH SAND AND EARTH

BY

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This is to certify that the thesis prepared in the Department of Theoretical and Applied Mechanics by KINGSLEY ABNER BURNELL entitled The Transmission of Pressure through Sand and Earth is approved by me as fulfilling this part of the requirements for the degree of Bachelor of Science in Civil Engineering.

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THE TRANSMISSION OF PRESSURE THROUGH SAND AND EARTH.

1. INTRODUCTION.

When a concentrated load is placed on a layer of sand, the pressure is transmitted from grain to grain to the supporting bed or surface. The pressure is usually assumed to be distributed over an area larger than that of the applied load. The actual distribution of the pressure on the supporting surface is not known. It is the purpose of these experiments to find the distribution of pressure through the sand and earth and also to find a suitable and satisfactory method of carrying on experiments.

Since the solution of the problem will not be made by any one set of experiments, but rather by a large number of comparable tests extending over a considerable length of time, this thesis is intended more as a beginning for such a series of tests and for the determination of the best method of procedure than as a complete solution of the problem.

The subject will be discussed under the following heads: II. Description of Apparatus and Method used, III. Experimental Data and Discussion, and IV. Conclusions.

On account of the limited time the experiments with earth were not carried out.

II Description of Apparatus and Method used.

A floor (figure 1,D.) 7×9 feet of two inch pine planks was built on six I-beams spaced twelve inches edge to edge of flange. The two center I-beams (K) were twelve inch and the other four, two on each side, were eight inch blocked up so that their top flange was on an exact level with the two twelve inch beams. A 1×8 inch board (E) was nailed around the edge of the floor to keep the sand from running off.

A circular hole about 4 1/16 inches in diameter was made in the center of one of the planks three feet from one end of the floor and midway between the two 12 inch I-beams. The hole was fully beveled so that a four inch plug (B) set in it had plenty of play for a small lateral or tipping movement. The plug which was about six inches long with its top just flush with the upper surface of the floor, rested on a knife edge (C) of a wooden lever arm (A) 4×4 inches. One end of the lever arm five feet from the knife edge rested on a pair of platform scales (F) while the other end, one foot from the knife edge, was supported by a fulcrum (G) hung from the floor by means of two bolts (H).

This was thought to be the proper method of supporting the fulcrum so that if the floor gave a little when pressure was applied, the fulcrum and lever arm resting on it would give with it.

Overhead a 24 inch I-beam (L) was fastened to the 10 inch I-beams (M) of the floor above by means of straps

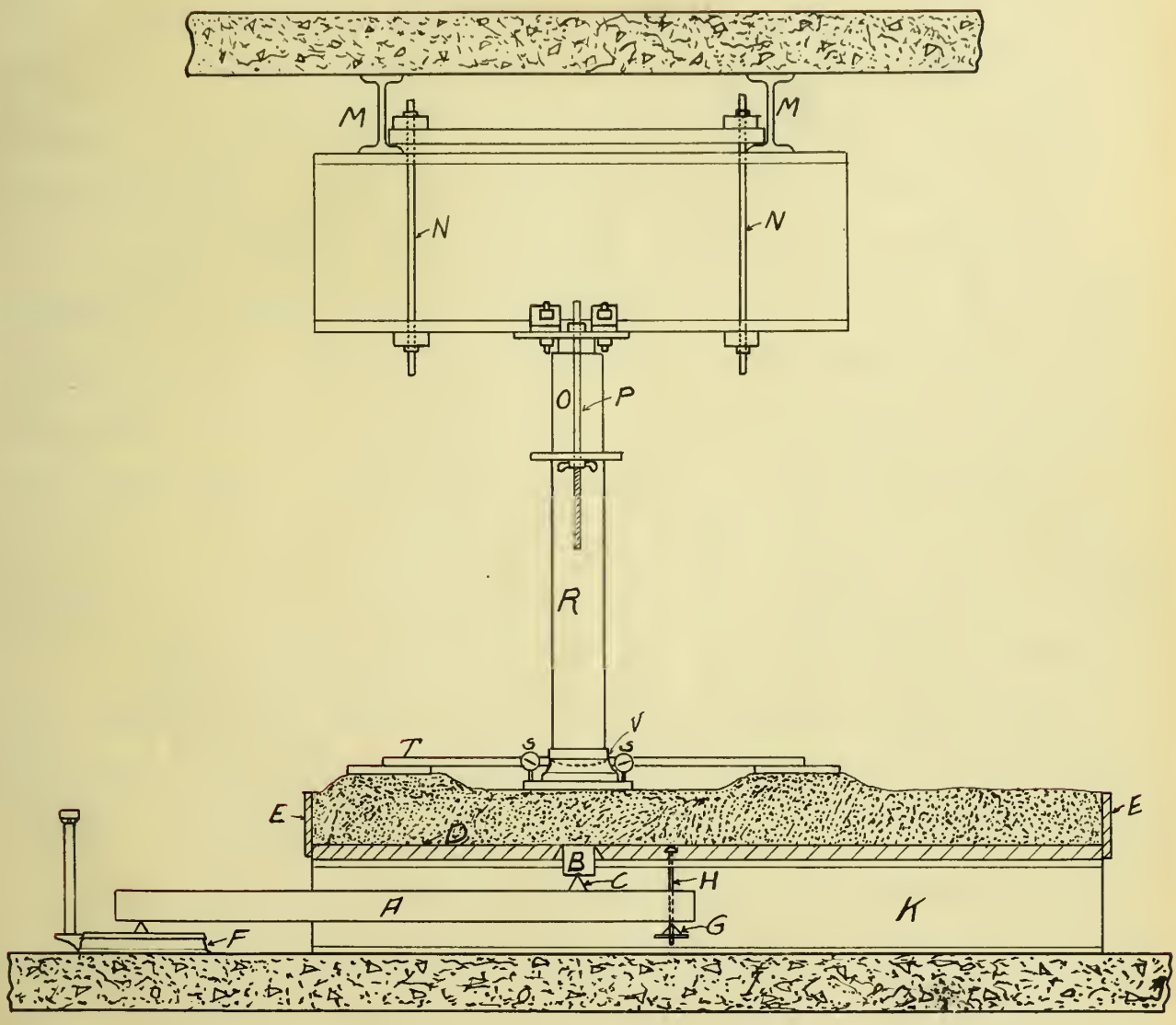


Figure 1.

(N). The beam was hung so that it was immediately over the center line of the lever arm and plug and on it was marked a point directly over the center of the plug. From this point other points were marked along the beam six inches apart. A hydraulic jack (O), using oil, was fastened to the lower flange of the 24 inch I-beam by means of straps (P) so that it could be moved along the beam in order to change the position of the load.

Building paper was laid on top of the floor to prevent the sand from flowing through any cracks and strips of thin sheet rubber about three inches wide were put over the plug so that the sand could not get between the plug and the edges of the hole to prevent a perfectly free motion of the plug. Mortar sand, practically dry and well tamped was put on the wooden floor to a depth of six inches.

The sand over the plug was leveled with an ordinary carpenter's level and a circular plate thirteen and one-half inches in diameter and three-quarters of an inch thick was placed on the sand. This plate was centered over the plug by means of a plumb bob hung from the mark above on the 24 inch I-beam. On top of the plate was put a spherical compression block (V) so as to help in centering the pressure and a wooden strut (R) 8×8 inch was put in between the compression block and the bottom of the jack.

Pressure was applied by means of the pump connected to the jack, and the readings of the pressure on the plug were taken from the platform scales. The jack and plate were then moved twelve inches from the center of the plug and pressure again applied.

It was here found that something was materially wrong, for the scale readings were higher with no pressure on the sand than they were with a pressure of 5500 pounds. After investigation, it was found that the pressure being applied directly over the fulcrum (since both were twelve inches from the center of the plug) caused it to settle, thus allowing the lever arm to draw away from the plug which in turn fell away from the sand and so relieved the pressure on the plug.

This was remedied by placing the fulcrum on the concrete floor (figure 2,I.) so that the pressure from above would not effect it's stability. The lever arm (A) was also changed so that the readings of the scale would be larger. A 3 inch I-beam was used this time with the knife edge (C) three and one half feet from one end and seven feet from the other end thus making the ratio of the arms 1 to 3. The actual pressure on the plug would then be three times that shown by the scales.

Experiments were then made with the pressure applied directly over the plug and at points six, twelve, eighteen, and twenty-four inches from the plug and for the same points with the layers of sand six, twelve and eighteen inches deep. After these tests were completed, similiar tests were run with the sand in a saturated condition.

Three extensometers (S) at third points on the plate fastened to strips of wood (T) which were supported on the sand at a couple of feet from the plate showed to what extent the plate sank into the sand.

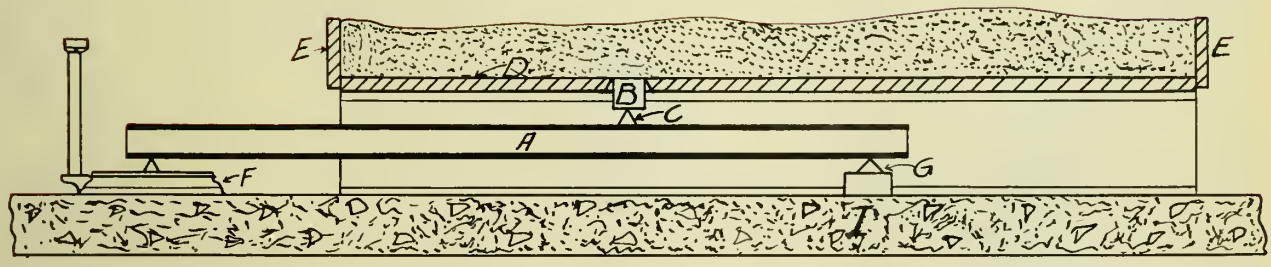


Figure 2.

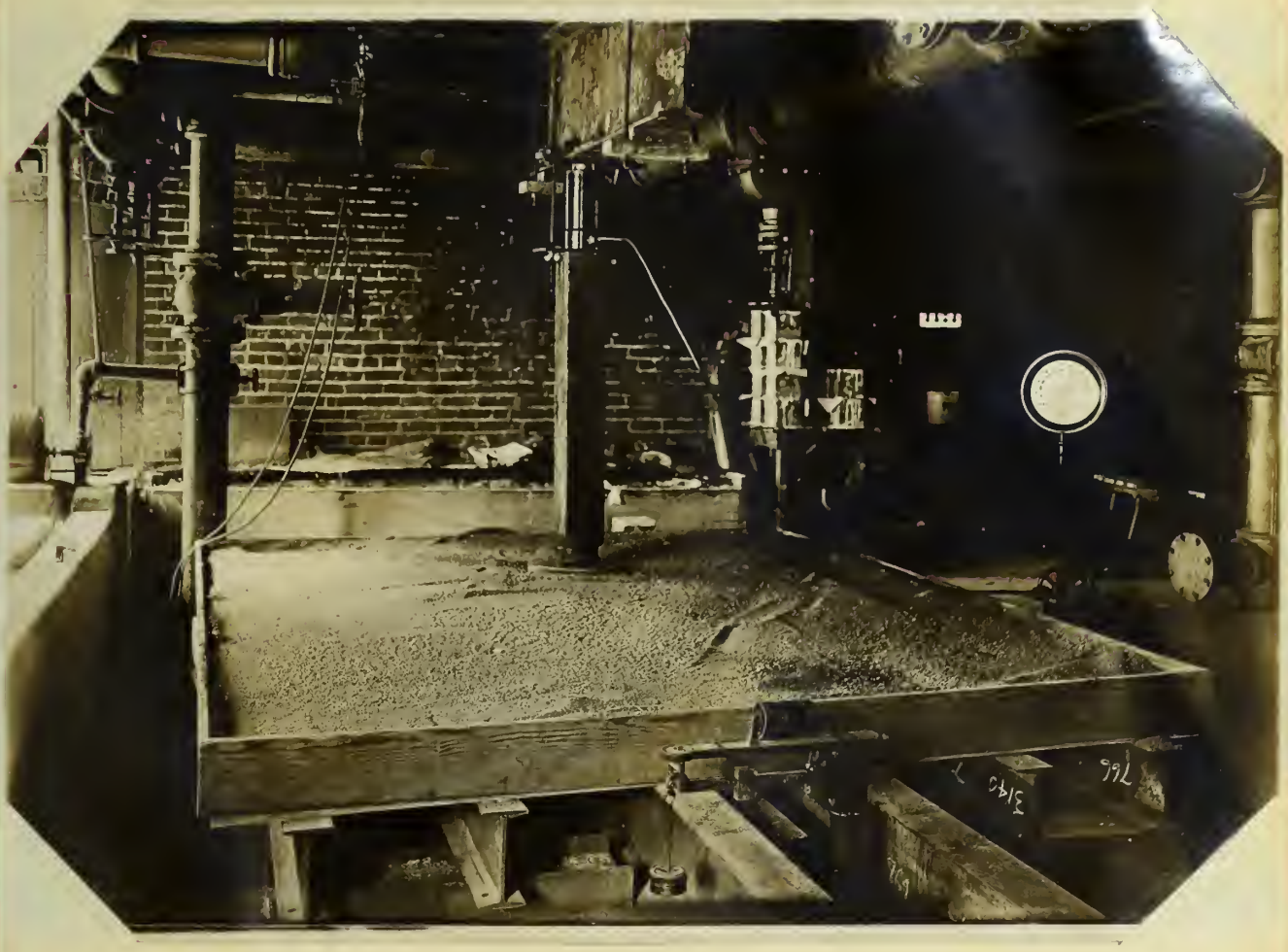


Photo of Apparatus.

III. Experimental Data and Discussion.

In the following tables the values of the pressure is the average result of from four to six tests.

The values in column 5 are those pressures on the plug due to the applied load and are obtained by subtracting the zero scale reading from the reading for that load in column 1 and multiplying the result by three, since the ratio of the lever arm is 1 to 2. The values in column 1 are used as these are considered more accurate than those in column 2 due to the fact that when the pressure is released, friction in the jack keeps the piston from moving until the load has been decreased usually from 1000 to 1500 pounds.

Column 6 gives the unit pressure on the plug (area 1.256 sq. in.) and column 4 gives the unit pressure of the applied load on the plate (area 144.00 sq. in.).

Table 1.

Dry Sand 6" deep.

Jack 0" from plug.

Av. Scale Rdg. up lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs/sq. in.	Actual pres on plug. lbs.	Actual pres. on plug lbs./sq. in.
43.5	43.5	0	0	0	0
95.6	96.4	500	3.47	156.3	12.45
111.4	129.0	1000	6.95	203.7	16.45
127.2	149.0	1500	10.41	251.1	20.00
142.0	163.2	2000	13.88	295.5	23.50
155.8	173.8	2500	17.36	335.4	26.70
165.4	182.8	3000	20.81	365.7	29.10
175.8	190.6	3500	24.30	396.9	31.60
184.4	198.4	4000	27.75	422.7	33.70
190.8	202.4	4500	31.21	441.9	35.15
197.4	203.2	5000	34.70	461.7	36.70
204.2	204.2	5500	38.20	482.1	38.30

Table 2.

Dry Sand 6" deep.

Jack 6" from plug.

Av. Scale Rdg. up. lbs	Av. Scale Rdg. down. lbs.	Jack Reading. lbs	Jack Reading. lbs/sq. in.	Actual pres on plug lbs.	Actual pres. on plug. lbs/sq. in.
37.5	37.5	0	0	0	0
40.0	41.0	500	3.47	7.5	0.59
43.7	48.4	1000	6.95	18.6	1.48
49.6	59.0	1500	10.41	36.3	2.89
57.6	67.8	2000	13.88	60.3	4.80
63.6	76.8	2500	17.36	78.3	6.23
72.4	88.0	3000	20.81	104.7	8.33
80.0	94.8	3500	24.30	127.5	10.15
86.6	102.8	4000	27.75	147.3	11.75
93.4	104.8	4500	31.21	167.7	13.34
99.6	105.8	5000	34.70	186.3	14.83
105.8	105.8	5500	38.20	204.9	16.30

Table 3.

Dry Sand 6" deep.

Jack 12" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Reading. lbs.	Jack Reading. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
36.64	36.64	0	0	0	0
36.72	36.60	500	3.47	0.24	0.019
36.86	36.60	1000	6.95	0.66	0.053
37.16	36.69	1500	1041	1.56	0.12
37.69	36.75	2000	13.88	3.15	0.25
38.06	36.81	2500	17.36	4.26	0.34
38.53	37.09	3000	20.81	5.67	0.45
39.12	37.56	3500	2430	7.44	0.59
39.62	38.25	4000	27.75	8.94	0.71
40.09	39.94	4500	31.21	10.35	0.83
40.31	40.37	5000	34.70	11.01	0.88
41.37	41.37	5500	38.20	14.19	1.13

Table 4.

Dry Sand 12" deep.

Jack 0" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg down. lbs.	Jack Reading. lbs.	Jack Reading. lbs./sq. in	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in
50.0	50.0	0	0	0	0
65.9	65.9	500	3.47	47.7	3.79
71.2	74.8	1000	6.95	63.6	5.06
77.0	83.3	1500	10.41	81.0	6.45
83.6	87.9	2000	13.88	100.8	8.03
89.6	93.6	2500	17.36	118.8	9.46
94.6	98.6	3000	20.81	133.8	10.63
98.8	101.6	3500	24.30	146.4	11.65
102.8	105.6	4000	27.75	158.4	12.60
106.8	108.6	4500	31.21	170.4	13.56
110.0	112.4	5000	34.70	180.0	14.32
114.8	114.8	5500	38.20	194.4	15.48

Table 5.

Dry Sand 12" deep.

Jack 6" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Reading lbs.	Jack Reading. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
41.2	41.2	0	0	0	0
51.6	53.0	500	3.47	31.2	2.48
56.8	61.3	1000	6.95	46.8	3.73
63.0	67.8	1500	10.41	65.4	5.20
70.0	71.7	2000	13.88	86.4	6.85
73.2	75.3	2500	17.36	96.0	7.63
77.2	78.8	3000	20.81	108.0	8.60
80.8	81.8	3500	24.30	118.8	9.42
84.3	85.0	4000	27.75	129.3	10.30
87.5	88.8	4500	31.21	138.9	11.05
90.3	91.7	5000	34.70	147.3	11.73
94.2	94.2	5500	38.20	159.0	12.65

Table 6.

Dry Sand 12" deep.

Jack 12" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Reading. lbs.	Jack Reading. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
37.9	37.9	0	0	0	0
38.3	38.1	500	3.47	1.2	0.096
39.6	39.2	1000	6.95	5.1	0.41
41.5	40.9	1500	10.41	10.8	0.87
43.1	43.0	2000	13.80	15.6	1.24
44.7	45.6	2500	17.36	20.4	1.62
46.7	48.2	3000	20.81	26.4	2.10
48.6	50.5	3500	24.30	32.1	2.56
50.0	52.4	4000	27.75	36.3	2.89
51.5	53.4	4500	31.21	40.8	3.25
52.9	53.9	5000	34.70	45.0	3.58
54.3	54.3	5500	38.20	49.2	3.91

Table 7.

Dry Sand 12" deep.

Jack 18" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
37.4	37.4	0	0	0	0
37.5	37.5	500	3.47	0.3	0.024
38.0	37.8	1000	6.95	1.8	0.14
38.5	38.3	1500	10.41	3.3	0.26
39.0	38.6	2000	13.88	4.8	0.38
39.3	38.9	2500	17.36	5.7	0.45
39.9	39.7	3000	20.81	7.5	0.59
40.4	40.2	3500	24.30	9.0	0.72
4.07	4.07	4000	27.75	9.9	0.79
41.1	4.09	4500	31.21	11.1	0.88
41.3	4.11	5000	34.70	11.7	0.93
41.5	41.5	5500	38.20	12.3	0.98

Table 8.

Sand 18" deep.

Jack 0" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
47.0	47.0	0	0	0	0
52.0	52.0	500	3.47	15.0	1.19
53.4	55.8	1000	6.95	19.2	1.53
55.4	59.7	1500	10.41	25.2	2.01
57.6	62.1	2000	13.88	31.8	2.53
59.9	64.8	2500	17.36	38.7	3.08
62.7	67.9	3000	20.81	47.1	3.75
65.2	69.6	3500	24.30	54.6	4.35
67.3	71.3	4000	27.75	60.9	4.85
69.0	72.1	4500	31.21	66.0	5.25
70.6	72.3	5000	34.70	70.8	5.63
73.3	73.3	5500	38.20	78.9	6.28

Table 9.

Dry Sand 18" deep.

Jack 6" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
46.0	46.0	0	0	0	0
52.0	52.2	500	3.47	18.0	1.43
56.1	57.5	1000	6.95	30.3	2.41
59.8	61.3	1500	10.41	41.4	3.29
63.0	64.0	2000	13.88	51.0	40.6
65.3	66.3	2500	17.36	57.9	4.61
68.0	68.8	3000	20.81	66.0	5.25
69.8	70.7	3500	24.30	71.4	5.68
71.4	71.8	4000	27.75	76.2	6.07
73.5	73.8	4500	31.21	82.5	6.57
75.0	75.7	5000	34.70	87.0	6.93
76.8	76.8	5500	38.20	92.4	7.35

Table 10.

Dry Sand 18" deep.

Jack 12" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
39.0	39.0	0	0	0	0
40.3	40.1	500	3.47	3.9	0.31
42.1	42.0	1000	6.95	9.3	0.74
44.1	44.0	1500	10.41	15.3	1.22
45.8	45.7	2000	13.88	20.4	1.63
47.3	47.2	2500	17.36	24.9	1.98
48.8	48.3	3000	20.81	29.4	2.34
49.9	49.4	3500	24.30	32.7	2.60
51.0	50.5	4000	27.75	36.0	2.86
52.0	51.7	4500	31.21	39.0	3.11
52.8	52.8	5000	34.70	41.4	3.30
53.8	53.8	5500	38.20	44.4	3.54

Table 11.

Dry Sand 18" deep.

Jack 18" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
38.0	38.0	0	0	0	0
38.29	38.25	500	3.47	0.87	0.069
38.83	38.71	1000	6.95	2.49	0.198
39.33	39.00	1500	10.41	3.99	0.32
39.83	39.25	2000	13.88	5.49	0.44
40.33	39.62	2500	17.36	6.99	0.56
40.62	40.06	3000	20.81	7.86	0.63
41.10	40.46	3500	24.30	9.30	0.74
41.37	41.08	4000	27.75	10.11	0.89
41.71	41.46	4500	31.21	11.13	0.96
42.00	42.10	5000	34.70	12.00	0.96
42.33	42.33	5500	38.20	12.99	1.03

Table 12.

Dry Sand 18" deep.

Jack 24" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings lbs.	Jack Readings lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
39.2		0	0	0	0
39.41		500	3.47	0.63	0.05
39.80		1000	6.95	1.80	0.14
40.25		1500	10.41	3.15	0.25
40.50		2000	13.88	3.90	0.31
40.73		2500	17.36	4.59	0.37
40.87		3000	20.81	5.01	040
41.00		3500	24.30	5.40	0.43
*		4000 *			
* Plate sank 2 or 3 inches in sand, and sand broke down 4 different times, so couldn't take readings going down.					

Table 13.

Saturated Sand 6" deep.

Plate sank 0.40" Jack 0" from plug.

Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
46.9	46.4	0	0	0	0
71.0	83.0	500	3.47	72.3	5.77
97.5	129.0	1000	6.95	151.8	12.10
119.0	159.5	1500	10.41	216.3	17.25
141.0	174.0	2000	13.88	282.3	22.50
155.0	193.5	2500	17.36	324.3	25.82
174.0	207.0	3000	20.81	381.3	30.32
189.5	217.5	3500	24.30	427.8	34.05
203.7	234.2	4000	27.75	470.4	37.45
221.0	243.2	4500	31.21	522.3	41.60
233.3	250.8	5000	34.70	559.2	44.60
251.2	251.2	5500	38.20	612.9	48.75

Table 14.

Saturated Sand 6" deep.

Plate sank 0.27" Jack 6" from plug.

Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Reading. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
38.4	37.8	0	0	0	0
52.6	52.5	500	3.47	42.6	3.39
64.3	70.8	1000	6.95	77.7	6.18
77.3	86.7	1500	10.41	116.7	9.28
90.5	98.0	2000	13.88	156.3	12.45
101.5	108.7	2500	17.36	189.3	15.08
113.5	126.5	3000	20.81	225.3	17.94
121.9	135.5	3500	24.30	250.5	19.95
132.5	139.0	4000	27.75	282.3	22.50
143.0	151.2	4500	31.21	313.8	24.98
154.0	158.3	5000	34.70	346.8	27.61
162.8	162.8	5500	38.20	373.2	29.70

Table 15.

Saturated Sand 6" deep.

Plate sank 0.18" Jack 12" from plug.

Av. Scale Rdg. up lbs.	Av. Scale Rdg. down lbs.	Jack Readings lbs.	Jack Readings lbs./sq. in.	Actual pres. on plug lbs.	Actual pres. on plug lbs./sq. in.
36.85	36.37	0	0	0	0
37.44	36.94	500	3.47	1.77	0.141
38.25	37.27	1000	6.95	4.20	0.334
39.19	37.46	1500	10.41	7.02	0.558
40.16	37.78	2000	13.88	9.93	0.791
41.06	38.40	2500	17.36	12.63	1.006
42.12	39.31	3000	20.81	15.81	1.260
42.94	40.4	3500	24.30	18.27	1.455
43.50	41.37	4000	27.75	19.95	1.586
44.10	42.19	4500	31.21	21.75	1.733
44.50	43.19	5000	34.70	22.95	1.825
44.88	44.88	5500	38.20	24.09	1.920

Table 16.

Saturated Sand 6" deep.

Plate sank 0.21" Jack 18" from plug.

Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down lbs.	Jack Readings lbs.	Jack Readings lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
37.00	36.83	0	0	0	0
37.25	36.83	500	3.47	0.75	0.060
37.29	36.83	1000	6.95	0.87	0.069
37.41	36.87	1500	10.41	1.23	0.098
37.54	36.96	2000	13.88	1.62	0.129
37.62	37.04	2500	17.36	1.86	0.148
37.83	37.17	3000	20.81	2.49	0.198
37.96	37.29	3500	24.30	2.88	0.229
38.08	37.50	4000	27.75	3.24	0.258
38.16	37.79	4500	31.21	3.48	0.277
38.25	38 0	5000	34.70	3.75	0.299
38.29	38.29	5500	38.20	3.87	0.308

Table 17.

Saturated Sand 12" deep.

Plate sank 0.02" Jack 0" from plug.

Av. Scale Rdg. up lbs.	Av. Scale Rdg. down lbs.	Jack Readings lbs.	Jack Readings lbs./sq.in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq.in.
47.3	49.0	0	0	0	0
65.0	84.5	500	3.47	53.1	7.25
83.5	116.8	1000	6.95	108.6	8.64
99.7	138.5	1500	10.41	157.2	12.50
115.7	155.5	2000	13.88	205.2	16.34
128.0	171.3	2500	17.36	242.1	19.30
144.0	184.2	3000	20.81	290.1	23.10
157.3	192.0	3500	24.30	330.0	26.30
170.8	203.0	4000	27.75	370.5	29.50
186.0	209.8	4500	31.21	416.1	33.15
202.5	212.8	5000	34.70	465.6	37.05
219.0	219.0	5500	38.20	515.1	41.00

Table 18.

Saturated Sand 12" deep.

Plate sank 0.18" Jack 6" from plug.

Av. Scale Rdg. up lbs.	Av. Scale Rdg. down lbs.	Jack Readings lbs.	Jack Readings lbs./sq.in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq.in.
41.0	42.0	0	0	0	0
51.5	66.6	500	3.47	31.5	2.51
60.3	75.3	1000	6.95	57.9	4.61
70.3	88.2	1500	10.41	87.9	7.00
80.5	100.8	2000	13.88	118.5	9.44
88.5	109.8	2500	17.36	142.5	11.34
99.5	119.3	3000	20.81	175.5	13.95
105.2	124.2	3500	24.30	192.6	15.35
113.2	131.2	4000	27.75	216.6	17.25
121.8	133.8	4500	31.21	242.4	19.30
130.8	136.0	5000	34.70	269.4	21.45
139.8	139.8	5500	38.20	296.4	23.60

Table 19.

Saturated Sand 12" deep.

Plate sank 0.145". Jack 12" from plug.

Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
38.1	38.0	0	0	0	0
39.3	38.9	500	3.47	3.6	0.286
40.6	40.3	1000	6.95	7.5	0.597
42.5	41.8	1500	10.41	13.20	1.05
44.5	43.5	2000	13.88	19.20	1.52
46.5	45.4	2500	17.36	25.20	2.006
48.6	48.3	3000	20.81	31.50	2.51
50.9	50.3	3300	24.30	38.40	3.06
52.9	52.8	4000	27.75	44.40	3.53
55.3	55.1	4500	31.21	51.60	4.11
57.0	57.3	5000	34.70	56.70	4.51
59.3	59.3	5500	38.20	63.6	5.07

Table 20.

Saturated Sand 12" deep.

Plate sank 0.21". Jack 18" from plug.

Av. Scale Rdg. up. lbs	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
37.08	37.00	0	0	0	0
37.25	37.00	500	3.47	0.51	0.041
37.48	37.04	1000	6.95	1.20	0.096
37.59	37.16	1500	10.41	1.53	0.122
37.75	37.25	2000	13.88	2.01	0.160
37.92	37.37	2500	17.36	2.52	0.201
38.17	37.58	3000	20.81	3.27	0.260
38.42	37.83	3500	24.30	4.02	0.320
38.56	38.25	4000	27.75	4.44	0.353
38.75	38.54	4500	31.21	5.01	0.399
38.83	38.66	5000	34.70	5.25	0.418
39.00	39.00	5500	38.20	5.76	0.458

Table 21.

Saturated Sand 18" deep.

Jack 0" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
67.6	67.6	0	0	0	0
73.0	70.3	500	3.47	16.2	1.29
78.0	82.6	1000	6.95	31.2	2.48
86.0	107.3	1500	10.41	55.2	4.38
95.0	115.6	2000	13.88	82.2	6.53
103.3	125.6	2500	17.36	107.1	8.53
111.0	134.0	3000	20.81	130.2	10.37
118.0	135.6	3500	24.30	151.2	12.04
125.0	136.3	4000	27.75	172.2	13.71
133.6	137.0	4500	31.21	198.0	15.75
143.3	143.3	5000	34.70	227.1	18.05
	In 3 tests plate sank 1.5"				

Table 22.

Saturated Sand 18" deep.

Jack 6" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
42.1	42.1	0	0	0	0
50.1	52.5	500	3.47	24.0	1.91
55.3	62.3	1000	6.95	39.6	3.15
62.5	75.3	1500	10.41	61.2	4.87
68.3	82.3	2000	13.88	78.6	6.26
74.0	88.5	2500	17.36	95.7	7.62
81.5	93.7	3000	20.81	109.2	8.70
86.9	100.3	3500	24.30	134.3	10.70
92.3	106.0	4000	27.75	150.6	12.00
99.3	107.7	4500	31.21	171.6	13.66
107.3	111.3	5000	34.70	195.6	15.55
	In 4 tests plate sank 0.75"				

Table 23.

Saturated Sand 18" deep.

Jack 12" from plug.					
Av. Scale Rdg. up. lbs	Av. Scale Rdg down lbs.	Jack Readings. lbs.	Jack Readings lbs./sq. in.	Actual pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
38.25	*	0	0	0	0
40.50		500	3.47	6.75	0.537
42.10		1000	6.95	11.55	092
44.10		1500	10.41	17.55	1.397
46.10		2000	13.88	23.55	1.875
48.00		2500	17.36	29.25	2.33
49.90		3000	20.81	34.95	2.78
52.00		3500	24.30	41.25	3.28
54.30		4000	27.75	48.15	3.83
56.60		4500	31.21	55.05	4.38
58.60		5000	34.70	61.05	4.85
* Plate kept sinking so didn't get readings coming down.					

Table 24.

Saturated Sand 18" deep.

Jack 18" from plug.					
Av. Scale Rdg. up. lbs.	Av. Scale Rdg. down. lbs.	Jack Readings. lbs.	Jack Readings. lbs./sq. in.	Actual. pres. on plug. lbs.	Actual pres. on plug. lbs./sq. in.
38.0	*	0	0	0	0
39.0		500	3.47	3.0	0.239
39.6		1000	6.95	4.8	0.382
40.2		1500	10.41	6.6	0.525
40.8		2000	13.88	8.4	0.668
41.2		2500	17.36	9.6	0.763
41.3		3000	20.81	9.9	0.788
41.6		3500	24.30	10.8	0.860
42.0		4000	27.75	12.0	0.955
42.4		4500	31.21	13.2	1.05
* Plate sank rapidly after 4500#. Didn't take readings coming down					

In the following plates of curves the points of each curve are the unit pressures at different distances from the center of the plug for the same applied load.

A glance at the curves shows the pressure transmitted through the sand varies very uniformly with the intensity of the load.

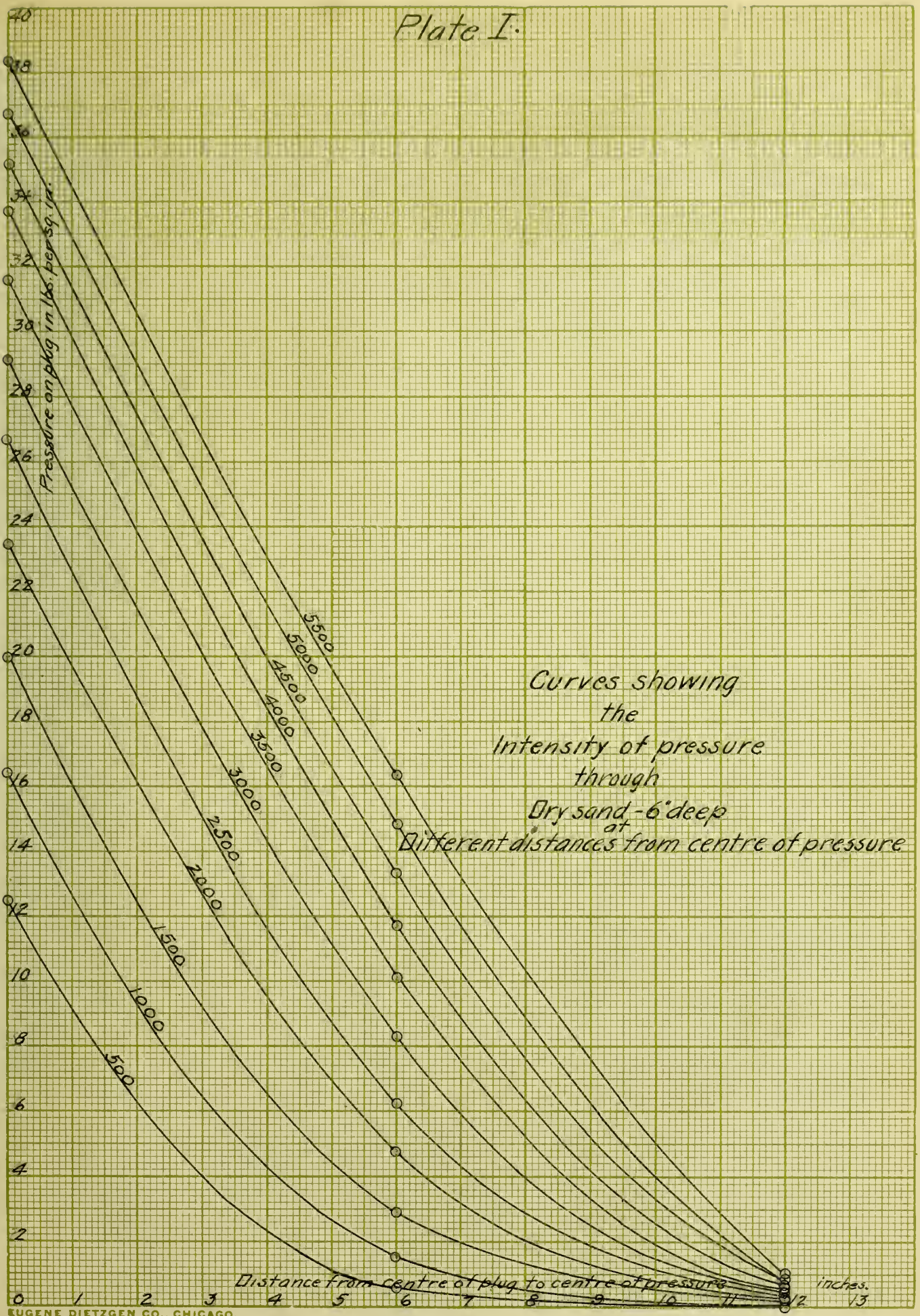
With dry sand having a depth of six inches (plate 1) it is seen that the curve is nearly a straight line. For twelve inches of depth (plate 2.) the curve is far from a straight line and the difference between the values of the intensity of pressure for the load directly over the plug and six inches from it is not so marked as for the sand six inches deep. With eighteen inches of sand (plate 3.) the values with the load applied directly over the plug are decided smaller than with the load six inches from the center of the plug. This shows that at a depth of twelve inches an arch action takes place which reduces the intensity of pressure directly under the load. A tendency towards arching is also shown for the smaller loads for a depth of twelve inches (plate 2).

With saturated sand having six inches of depth (plate 4), the pressure is distributed farther than with dry sand, for with the former a pressure is observed at eighteen inches from the center of the plug while with the latter none is observed. From twelve inches out to eighteen inches the intensity of pressure falls away very slowly as is seen by the very gradual slope of the curves. Also for twelve inches of saturated sand (plate 5) the intensity of pressure falls off quite gradually between the distances of twelve and

eighteen inches from the center of the plug. For eighteen inches of saturated sand (plate 6) the curves show a tendency towards arch action. For the smaller loads, 500 to 1500 pounds, the curves show that an arch action takes place but for the higher loads the arch is evidently broken down.

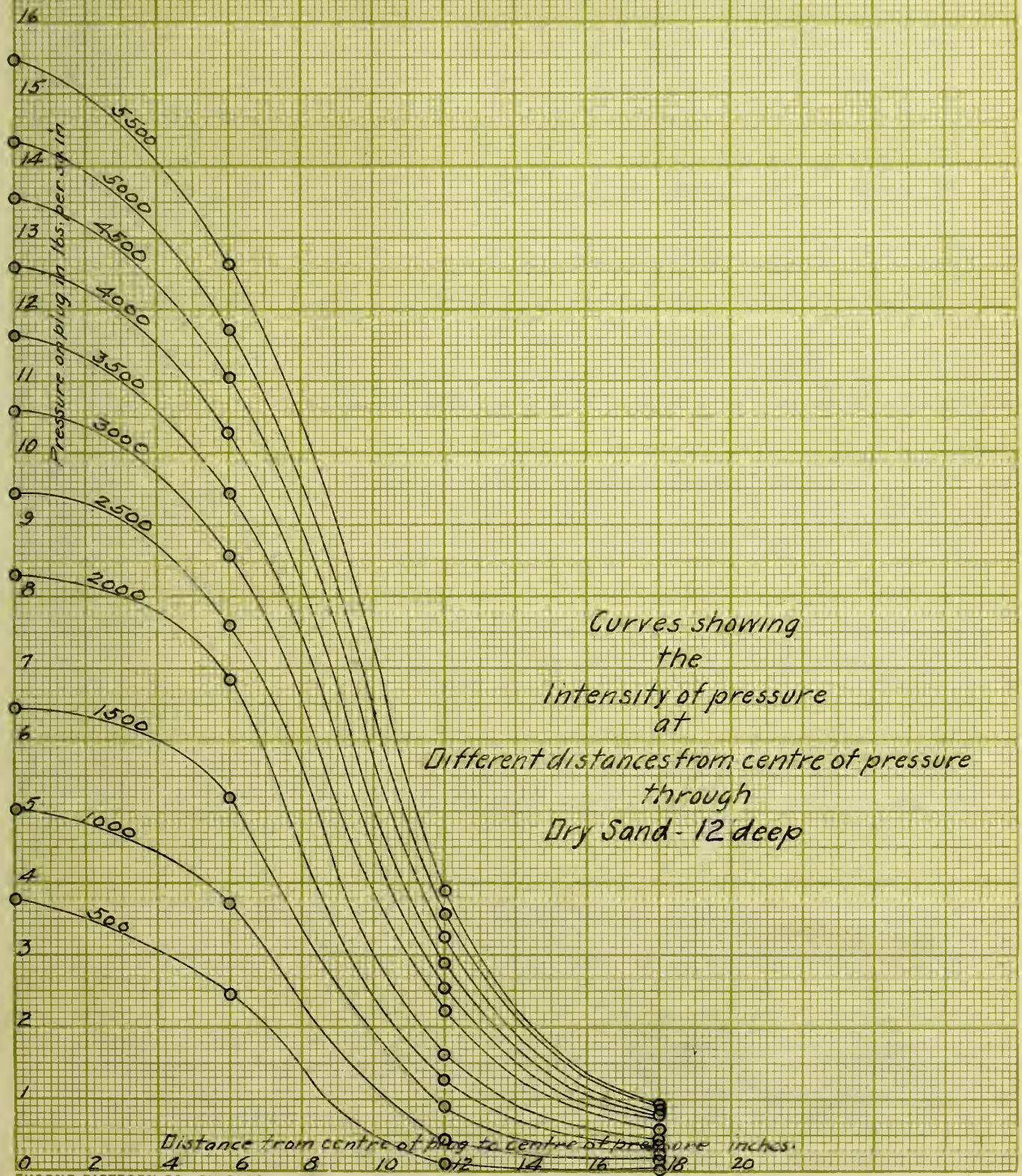
The tables and curves show that all the intensities of pressure for saturated sand are higher than are the intensities of pressure for the corresponding loads on the dry sand. This is probably due to the fact that the water has a lubricating effect on the particles of sand allowing them to slide more freely over each other.

Plate I.



EUGENE DIETZGEN CO., CHICAGO.

Plate II



Curves showing
the
Intensity of pressure
at
Different distances from centre of pressure
through
Dry Sand - 12 deep

Plate III

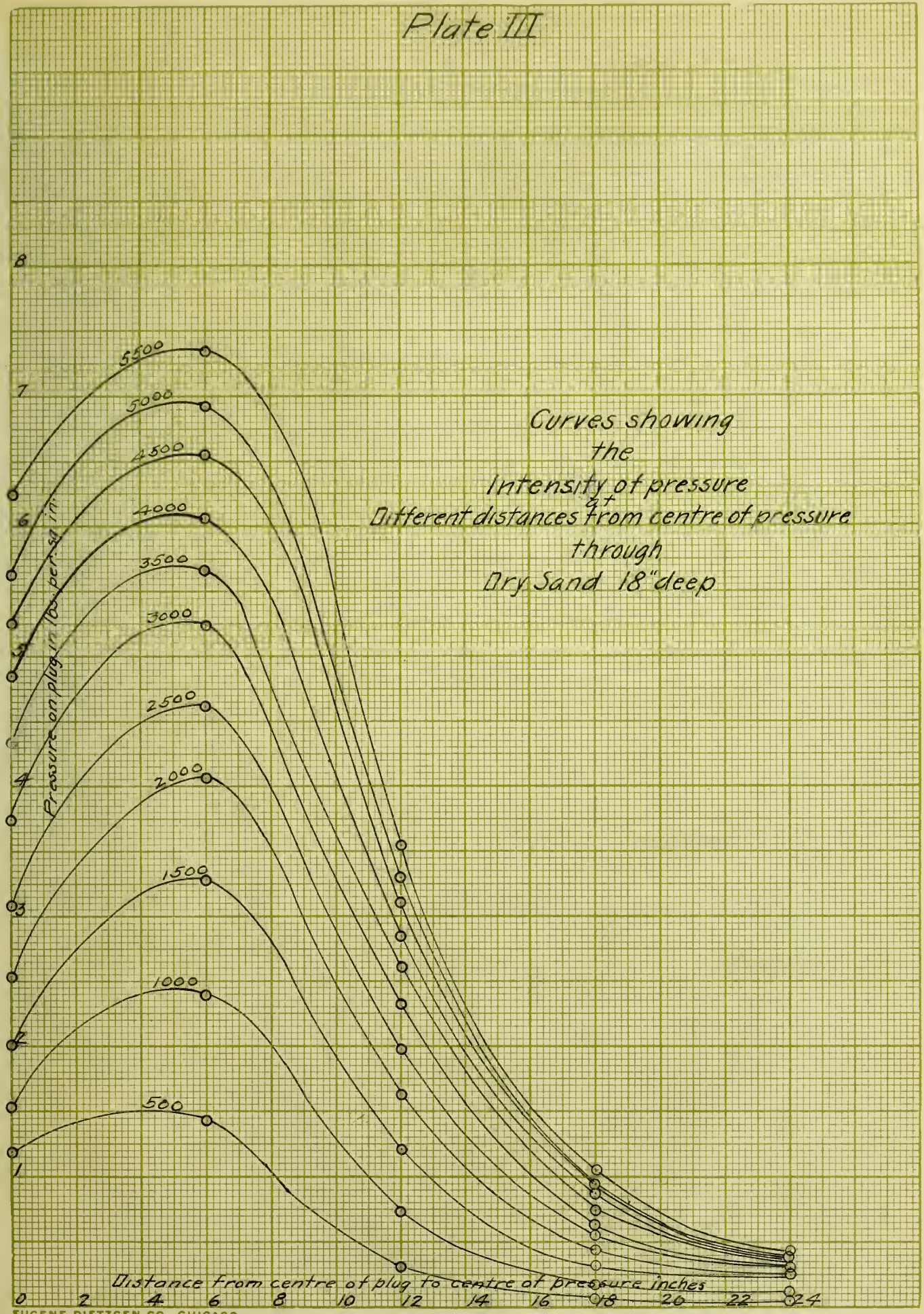
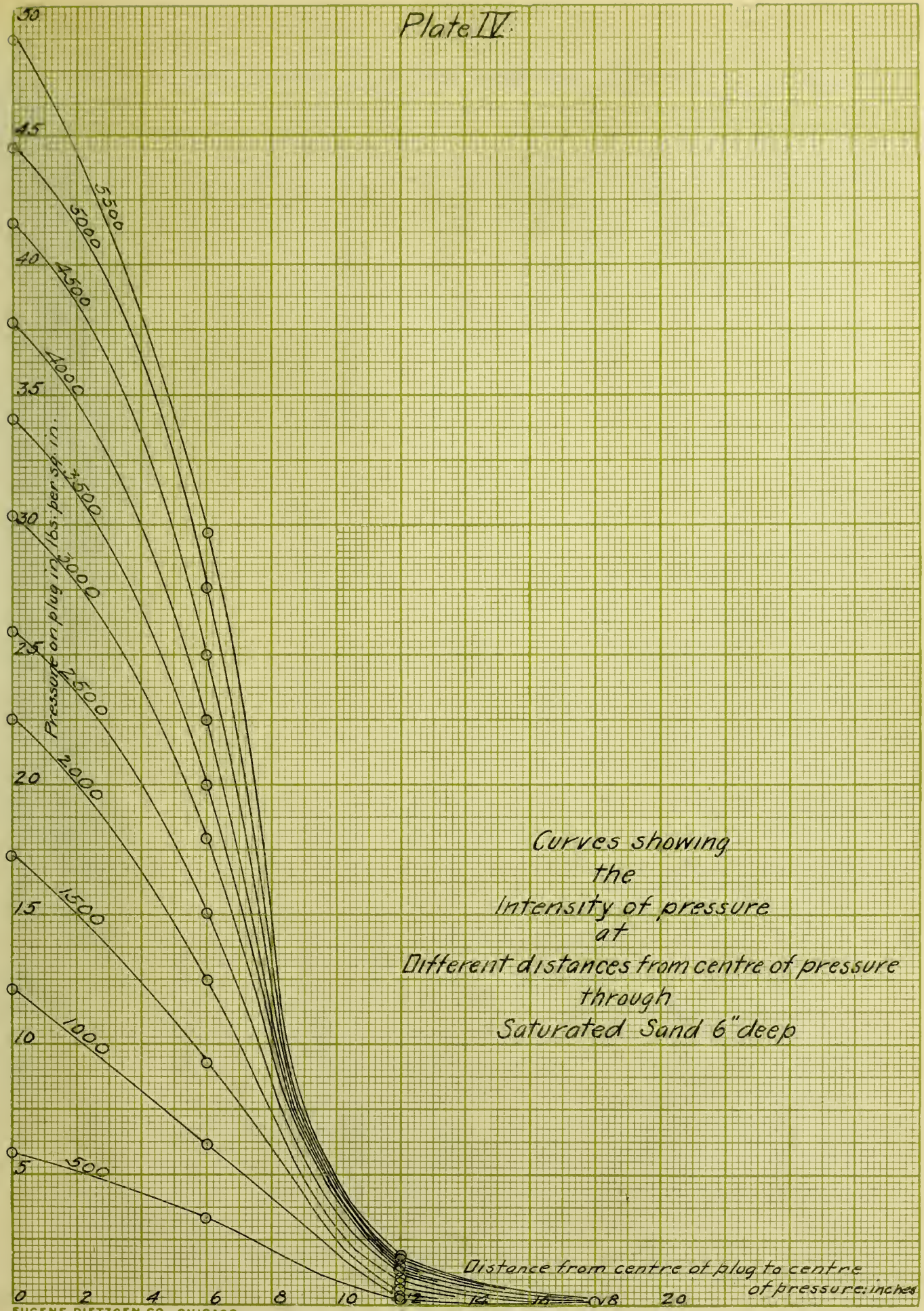


Plate IV.



Curves showing
the
Intensity of pressure
at
Different distances from centre of pressure
through
Saturated Sand 6" deep

EUGENE DIETZGEN CO., CHICAGO.

Plate V

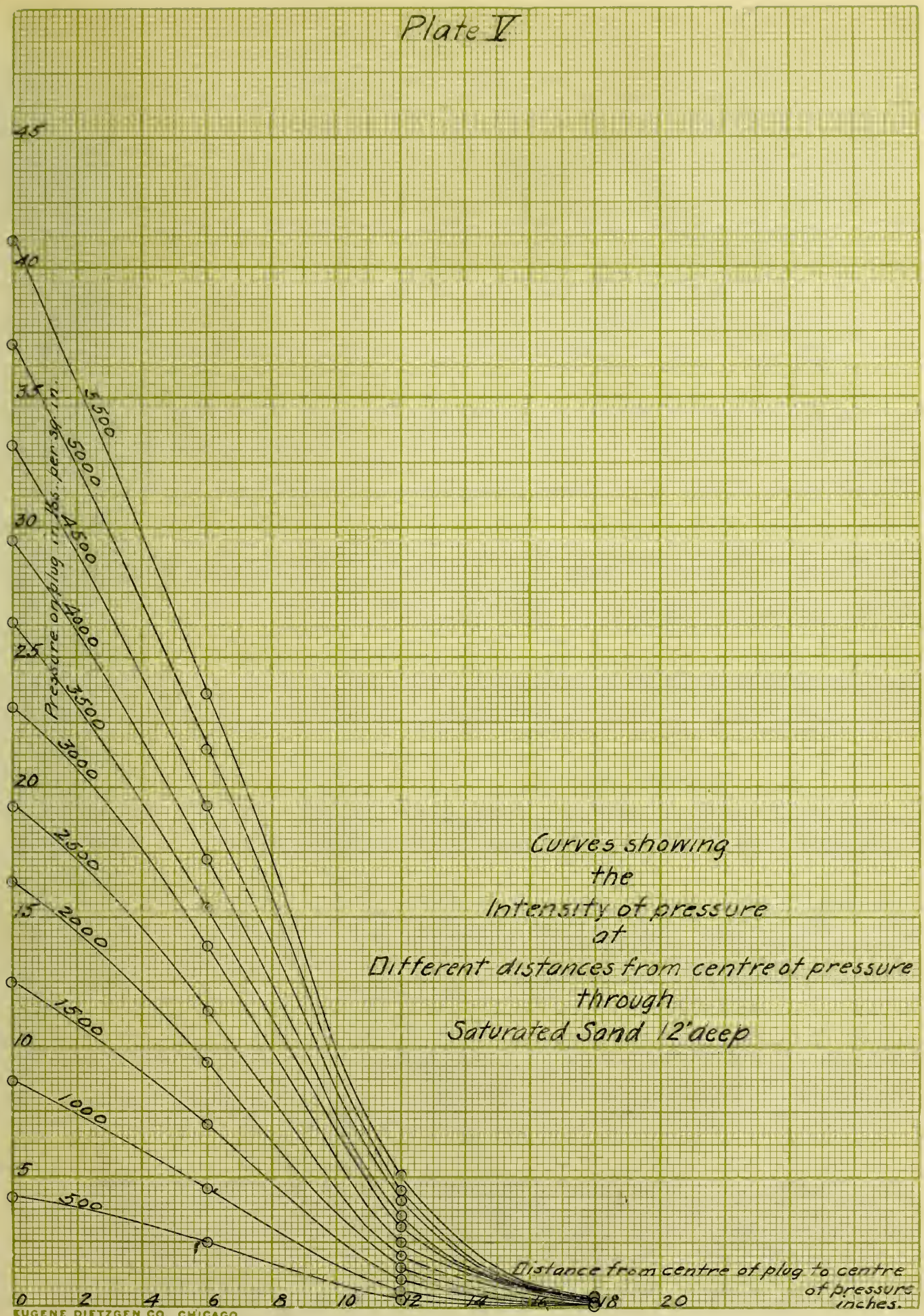


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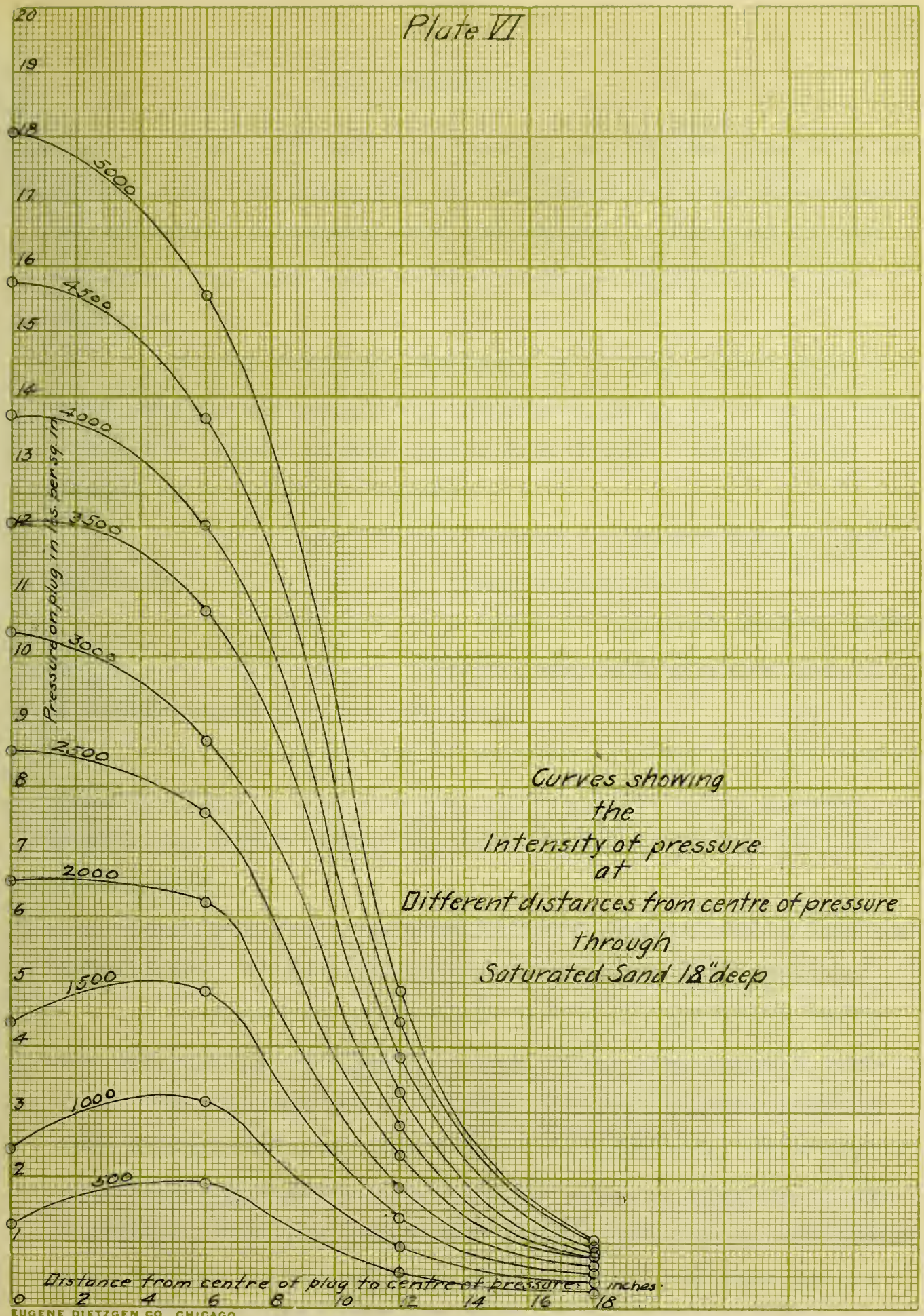
Plate VI



Curves showing
the
Intensity of pressure
at
Different distances from centre of pressure
through
Saturated Sand 18" deep

EUGENE DIETZGEN CO., CHICAGO.

IV. CONCLUSIONS.

When a pressure is tramsnitted through sand to a bed or surface, the intensity of the pressure on the bed varies at different distances from the center of pressure of the applied load, but this intensity is not inversely as the distance.

2. The pressure decreases at a much slower rate beyond twelve inches from the center of pressure than it does from the center of pressure out to twelve inches (for depths up to eighteen inches).

3.For a depth of six inches to twelve inches there is no arch action shown by these experiments.

4.With dry sand at a depth of eighteen inches there is an arch action with a decided decrease of intensity of pressure directly under the load.

5. Saturated sand at eighteen inches of depth has a slight arch action for light loads, up to ten or eleven pounds per square inch, but for greater loads the arch is broken down.

6. For the same load greater intensities of pressure are transmitted through saturated sand than dry sand.

7. From the uniformity of the corresponding tests and the general similarity of the curves for various applied loads for the same depth of sand, the method used seems a very satisfactory one for further experiments. The method is also very satisfactory with regards to the handling of the apparatus. From the experience gained, the writer recommend that further experiments be carried on by the same method

and with a similiar apparatus.